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A population analysis of rock grenadier based on the
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A POPULATION ANALYSIS OF ROCK GRENADIER

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BASED ON THE GENETIC POLYMORPHISM

Information seulement

OF NONSPECIFIC ESTERASES AND MYOGENES

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The rock grenadier (Macrurus rupestris Gunn.) is a deep-sea species that occurs widely in the Northern Atlantic and it is an important commercial species. In order to exploit the rock grenadier efficiently, it is necessary to have some concept of its intraspecific structure. The best results that can be obtained at the present time, when studying a species' population structure, is by employing the method

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*Translator's note: Numbers in the right-hand margin refer to the corresponding page in the Russian text.

of biochemical genetics, in particular, the electrophoretic analysis of enzymes and nonenzyme proteins.

The four-allele codominant system of nonspecific esterases in the rock grenadier has already been described [Nefedov et al., 1976]. On the basis of this system, research was carried out on samples of rock grenadier from certain areas of the North Atlantic [Alekseev et al., 1979; Dushchenko, 1979]. During an analysis of the rock grenadier's myogenic water-soluble proteins (myogens), four polymorphic zones of activity were discovered, two of which are genetically determined two-allele and three-allele systems [Logvinenko et al., 1981].

The present paper examines the results of comparing rock grenadier samples from various portions of its geographic range on the basis of their polymorphic systems of myogenic nonspecific esterases and water-soluble proteins.

Material for this research was provided by approximately 5000 specimens of rock grenadier that were collected by commercial exploration vessels between 1974 and 1976 from trawl catches at a depth of 600 to 1500 m at 37 points in their geographic range (Figure 1). Specimens were sent in a frozen state to the laboratory and maintained at negative temperatures. The electrophoretic separation of the proteins was carried out in vertical slabs of polyacrylamide gel by the commonly accepted method, with modifications that have been described (Trueller and Nefedov, 1974; Nefedov, et al., 1976; and Logvinenko et al., 1981).

In comparing the number of phenotypes of nonspecific esterase observed in 37 rock grenadier samples with the number expected on the basis of the Hardy - Weinberg law, a discrepancy was found to occur

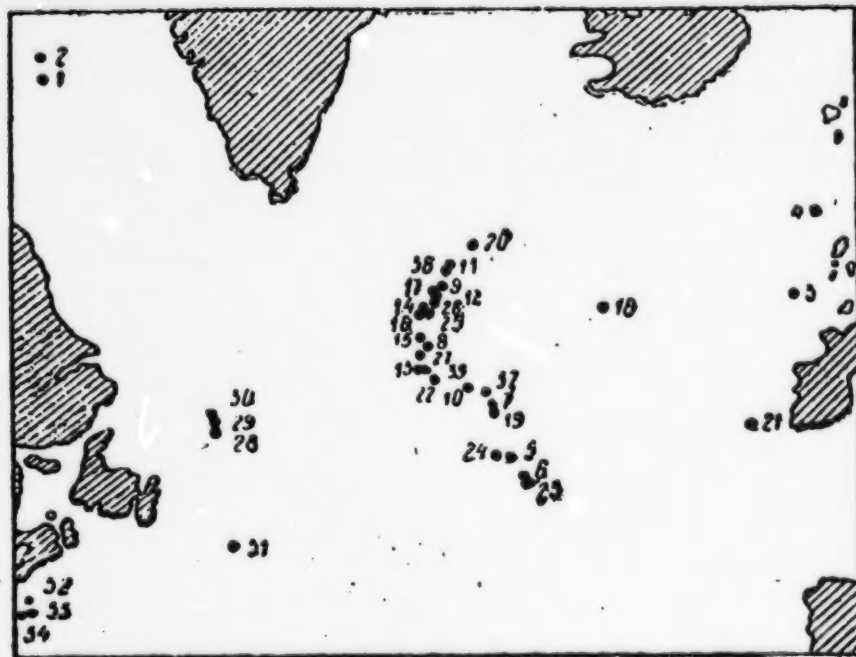


Figure 1: The points at which rock grenadier were collected in the North Atlantic.

in numerous cases - 15 out of 37 (Table 1). This was possibly due to the imprecise identification of the phenotypes. A considerable diversity in the intensity of coloring of the fractions was observed in the polymorphic locus of esterases. Intensive fractions often produce additional bands of less intensity, which can coincide with the basic fractions in mobility. This complicates the recognition of some phenotypes and can distort their actual ratio. Other factors could also cause the discrepancy between the observed and the expected numbers of phenotypes in this system. /30

When comparing the samples, we made use of the coefficient of similarity and the criteria of identity proposed by L.A. Zhivotovskii [1979], which make it possible to compare a population on the basis of morph frequency. The results of an unpaired comparison of all the samples in terms of the frequency of variants of esterases is given in Figure 2. First of all, we should note the small number of distinguishing samples. Differences with a probability greater than 0.99 were obtained in only 11 cases out of 666 comparisons (1.7 per cent) and with a probability of more than 0.95 in 62 cases (9.3 per cent), which indicates the low level of diversity among the samples in terms of esterase polymorphism. The most frequent alleles vary within narrow limits (B from 0.456 to 0.579 and C from 0.396 to 0.515). Based on the analysis of the material with regard to the polymorphic system of esterases, we can make the assumption that this species has a weak population structure.

An analysis of these same samples in regard to the polymorphic system of myogenes (Mu-1) produced different results. All of the samples proved equiponderant (Table 1). Allele frequencies varied

Table 1: The frequencies of alleles at loci Est-1 and Mu-1 in samples of rock grenadier from the North Atlantic:

Number of specimens	Frequency of alleles Est-1				χ^2	Number of specimens	Frequency of alleles Mu-1		χ^2
	A	B	C	D			A	B	
127	0,008	0,500	0,404	0,028	12,705	127	0,795	0,205	2,176
206	0,012	0,495	0,483	0,010	21,196	208	0,897	0,103	2,786
195	0,018	0,526	0,451	0,003	26,616	195	0,364	0,636	3,279
128	0,023	0,547	0,426	0,004	19,987	124	0,472	0,528	2,512
48	0	0,563	0,416	0,021	1,361	48	0,708	0,292	0,003
200	0,005	0,515	0,470	0,010	14,296	200	0,405	0,595	0,003
200	0,005	0,550	0,443	0,002	9,568	199	0,675	0,325	3,644
200	0,020	0,475	0,495	0,010	54,187	200	0,607	0,393	0,289
198	0,030	0,508	0,449	0,013	10,518	198	0,561	0,439	0,867
200	0,012	0,513	0,465	0,010	5,759	200	0,642	0,358	2,925
200	0,010	0,483	0,500	0,007	2,418	200	0,602	0,398	0,032
216	0,012	0,572	0,403	0,014	97,679	216	0,586	0,414	2,910
173	0,012	0,509	0,477	0,003	8,998	174	0,552	0,448	1,478
195	0,018	0,508	0,467	0,007	31,733	197	0,731	0,269	0,009
200	0,012	0,505	0,473	0,010	12,920	200	0,672	0,328	0,031
199	0,030	0,482	0,480	0,008	94,179	198	0,906	0,091	2,083
100	0,010	0,540	0,445	0,005	12,767	100	0,550	0,450	0,499
98	0,005	0,520	0,464	0,010	15,431	100	0,430	0,570	0,379
100	0,020	0,525	0,435	0,020	2,265	100	0,705	0,295	0,390
98	0,026	0,480	0,485	0,010	16,513	100	0,540	0,460	0,218
100	0,020	0,480	0,485	0,015	44,662	100	0,415	0,585	0,538
100	0,010	0,575	0,405	0,010	0,446	100	0,500	0,500	0,640
30	0	0,550	0,450	0	4,655	30	0,767	0,233	2,788
50	0,010	0,510	0,450	0,030	26,690	50	0,470	0,530	0,355
50	0,070	0,470	0,460	0	6,171	50	0,720	0,280	0,417
64	0,016	0,531	0,453	0	3,836	64	0,586	0,414	1,080
70	0,014	0,529	0,443	0,014	0,132	70	0,600	0,400	0,230
68	0,007	0,529	0,396	0	3,069	70	0,893	0,107	2,248
29	0,034	0,569	0,396	0	3,165	29	0,827	0,173	0,113
41	0,012	0,549	0,429	0	1,903	41	0,854	0,146	1,217
46	0	0,543	0,457	0	0,705	45	0,644	0,356	0,730
45	0,011	0,567	0,422	0,100	1,962	44	0,818	0,182	0,303
19	0	0,579	0,421	0	0,354	19	0,605	0,395	0,002
34	0,029	0,456	0,515	0	3,007	34	0,470	0,530	0,105
175	0,009	0,503	0,486	0,003	9,361	200	0,560	0,440	0,428
200	0,010	0,535	0,453	0,002	6,010	200	0,565	0,435	0,669
100	0	0,530	0,465	0,005	1,219	100	0,420	0,580	0,069

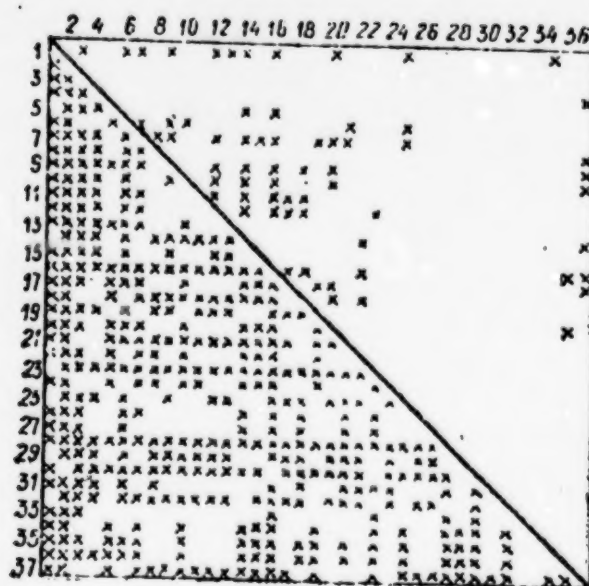


Figure 2: A comparison array of rock grenadier samples based on the criterion of identity. Non-specific esterases are above the diagonal line; myogens below. Crosses indicate comparison variants in which the probability of a difference is greater than 0.95. The numbers indicate the number of the sample.

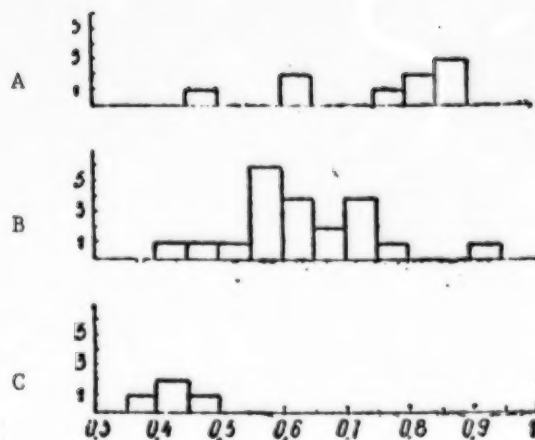


Figure 3: The distribution of samples in three regions of the North Atlantic based on the frequency of allele A at locus Mu-1:

A - western region;

B - region of the Central Atlantic Ridge; and,

C - eastern region.

The x-coordinate shows the frequency of allele A at locus Mu-1; the y-coordinate indicates the number of samples.

within large limits (A from 0.364 to 0.906). In a paired comparison of the samples based on the criterion of identity, differences with a probability greater than 0.99 were found in 336 cases out of 666 comparisons (50.5 per cent), and with a probability greater than 0.95 in 424 cases (63.7 per cent). These data indicate considerable diversity in rock grenadier samples within its geographic range.

Different regions of the North Atlantic (the western region, the eastern, and the region of the Central Atlantic Ridge) differ clearly in terms of the composition of samples with different frequencies of allele A at the locus My-1 (Figure 3). In the western portion of the geographic range the majority of samples (67 per cent) have a high frequency of allele A (more than 0.75). A minimum frequency for this allele (lower than 0.50) is characteristic of the eastern portion. The greatest diversity among samples in the frequency of allele A (from 0.405 to 0.906) is observed in the region of the Central Atlantic Ridge, but the majority of samples (75 per cent) fall within frequency limits between 0.550 and 0.750. Each of these regions possesses a grouping that is significantly distinct in the frequency of allele A at the locus My-1, as demonstrated by an analysis of the samples for heterogeneity. /32

Data on the frequency of phenotype B of the polymorphic system of esterases were also utilized to analyze the distribution of samples within the different regions in order to supplement the data on the frequency of allele A locus Mu-1. This phenotype can be identified unmistakably on phoregramms, and, although its frequency varies within relatively wide limits (from 0.250 to 0.400), it can serve as an objective supplementary parameter during analysis.

Table 2: An evaluation of non-uniformity among groupings of rock grenadier in the three regions of the North Atlantic on the basis of the frequency of allele A, $\mu=1$:

Region	Number of samples	Number of specimens	Frequency of allele A	Test for non-uniformity χ^2	ν
Western	9	617	0.812	106.285	8
Central	24	3394	0.610	349.042	23
Eastern	4	519	0.412	8.260	3
Total	37	4530	0.615	806.980	36

Note: ν indicates the number of degrees of freedom.

Figure 4: The distribution of rock grenadier samples at the coordinates of the frequencies of allele A, locus Mu-1 (the x-coordinate) and phenotype B of nonspecific esterases (the y-coordinate) in the different regions of the North Atlantic: (a) western; (b) northern section of the North Atlantic Ridge region; (c) southern section; and (d) eastern. The solid lines indicate representative sampling error.

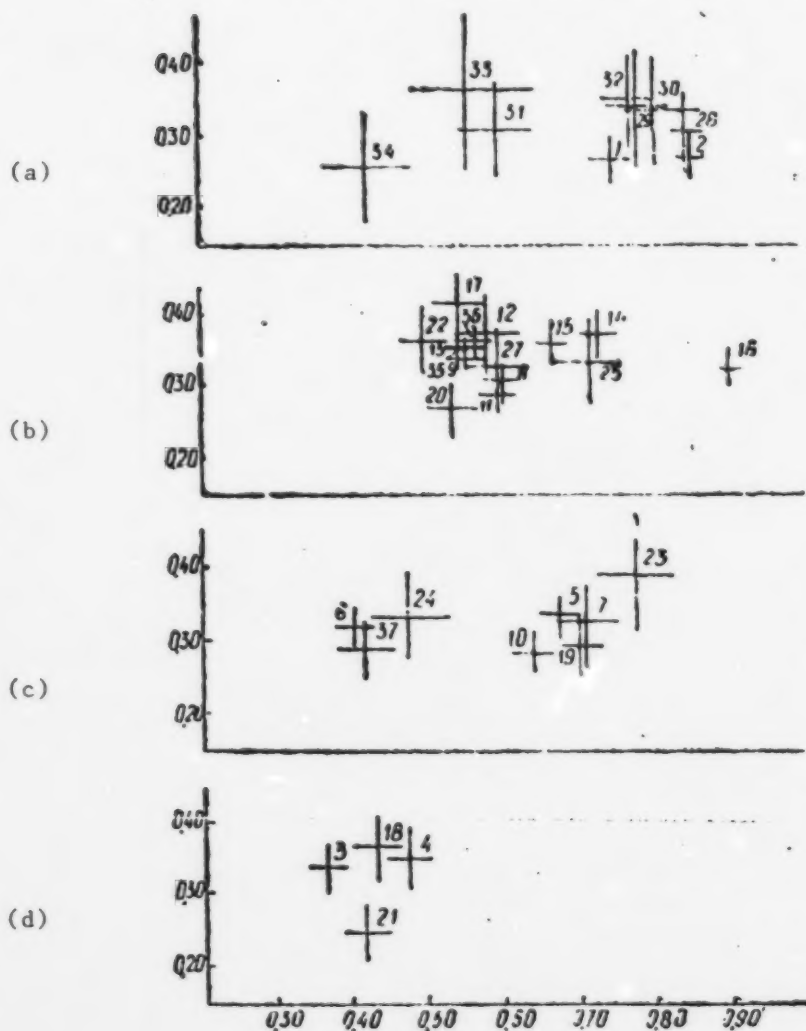


Figure 4a shows the distribution of samples from the western region with coordinates for frequencies of allele A at the locus My-1 and of phenotype B of esterases, with allowance made for representative error. It follows from this data that the samples that we analyzed do not belong to a single distribution, but were taken from several groupings of rock grenadier that were reproductively isolated. We should note that the similarity in the frequencies of the two features does not always match the geographical location of the samples.

Samples from the region of the Central Atlantic Ridge are shown in frequency coordinates in two graphs (Figures 4b and 4c) because this region is divided into two sections (a northern and a southern) by the relief of its floor, caused by the arching and faulting of the ridge. These data show that the samples were taken from different distributions, in both the northern and the southern sections of the Central Atlantic Ridge, which confirms the presence of several reproductively isolated groupings of rock grenadier.

Only four samples from the eastern region were analyzed, but even they were not a common unit (Figure 4d).

The characteristics of the spatial distribution of rock grenadier samples in the region of the Central Atlantic Ridge are shown in Figure 5.

CONCLUSION

In summation, we can conclude that the rock grenadier of the North Atlantic is divided into a number of reproductively isolated groupings. The question as to the number of these groupings can only be answered after more detailed research that takes into account



Figure 5: The distribution of rock grenadier samples in the region of the Central Atlantic Ridge. Samples that do not differ statistically in the features investigated are indicated by identical signs.

additional genetic markers. Besides the features that we employed, we can also recommend for research the three-allele system of myogenes (My-4) that has been discovered and described, the three-allele system of phosphoglucomutase, and the three-allele system of α -glycerophosphat- dihydrogenase. We studied these systems on three samples of rock grenadier (Nos. 35, 36, and 37) and in every case we obtained a correspondence between the observed phenotype numbers and the phenotype numbers expected on the basis of the Hardy - Weinberg law. The use of several genetic markers for analysis will provide a deeper understanding of the population structure of the rock grenadier---a valuable object of commercial fishing.

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The population analysis of grenadier based on genetic polymorphism of non-specific esterases and myogenes

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SUMMARY

The electrophoretic analysis was made of polymorphic systems of muscle esterases (Est - 1) and myogenes (My - 1) of the grenadier (*Macrurus rupestris* Gunn.) from samples taken in 37 localities in the North Atlantic. The differences at the locus Est - 1 were insignificant in the samples. A substantial variation was found at the locus My - 1 in the area investigated. The samples from the areas of the North Atlantic (western, central and east) differ by the frequency of allele A at the locus My - 1. In each area samples were divided into statistically distinguished groups which indicate the presence of several isolated populations of the grenadier. For further assays of the intraspecific structure of the species the polymorphic systems of myogenes (My - 1), phosphoglucomutases and L-glycerophosphate dehydrogenases found earlier are suggested.

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